VAGOTOMY FOR GASTRODUODENAL ULCER*

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A VOLUME to honor the 20 years of superb service that Dr. Dallas B. Phemister has given to the Department of Surgery and to the Medical School of the University of Chicago is fitting and appropriate. It is a great pleasure and a privilege for me to take part in this celebration, for I have been closely associated with him during all this time. We have worked together and what I have learned of surgery has come chiefly from him. He has taught best by example, and his modesty and industry, but best, his scientific integrity have set the standard, and this is chiefly responsible for the accomplishments of the Department. Sustained experimentation in the laboratory and honest observation and recording in the Clinic have constantly marked his way. Few men have done so well in both fields. Enthusiasm goes with him and the will to work. It is especially gratifying that this occasion looks upon him in the full flood of his powers and we hope that it will convey, even though faintly, our warm admiration and regard.

In previous papers[1] I have presented our early experience with surgical division of the vagus nerves in patients with gastroduodenal ulcer, together with brief descriptions of the operative technic involved. It is the purpose of this communication to survey the present status of this work and to refer to some studies in the laboratory that provide for the first time information concerning the relative importance of nervous and humoral factors in determining the volume and acidity of the gastric secretion.

The operation was undertaken because of the conviction, arrived at by experimental work on the lower animals, that pure gastric juice as it is secreted by the fundus of the stomach, has the capacity to destroy and digest various living tissues, including the wall of the jejunum, duodenum, and even the stomach itself.[2] It does not do this under normal conditions because the usual and appropriate stimulus to gastric secretion is the ingestion of food. This dilutes and neutralizes the gastric juice and decreases its corrosive powers. In normal man the secretion of gastric juice in the intervals between meals, when there is no food in the stomach or upper intestines, falls off to a small quantity that can be buffered by the saliva, pyloric mucus, and the regurgitated duodenal secretions. The chief secretory abnormality in ulcer patients lies not in the production of a juice with higher than normal acidity, nor even in the production of more normal juice in response to the usual stimuli, although there is some evidence that this occurs, but rather in the secretion of abnormally large amounts of gastric juice in the intervals between meals particularly at night when the stomach is empty and there is no obvious

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stimulant. The accumulation in the stomach of considerable amounts of such relatively pure fundic secretion obviously provides in man the counterpart of those experiments in animals where ulcers inevitably develop and become progressive.

The medical management of duodenal ulcer has been successful directly dependent upon the degree to which the acid gastric juice has been neutralized during the entire 24 hours. Surgical treatment, likewise, has been successful when a sufficient part of the fundus mucosa has been removed to reduce the

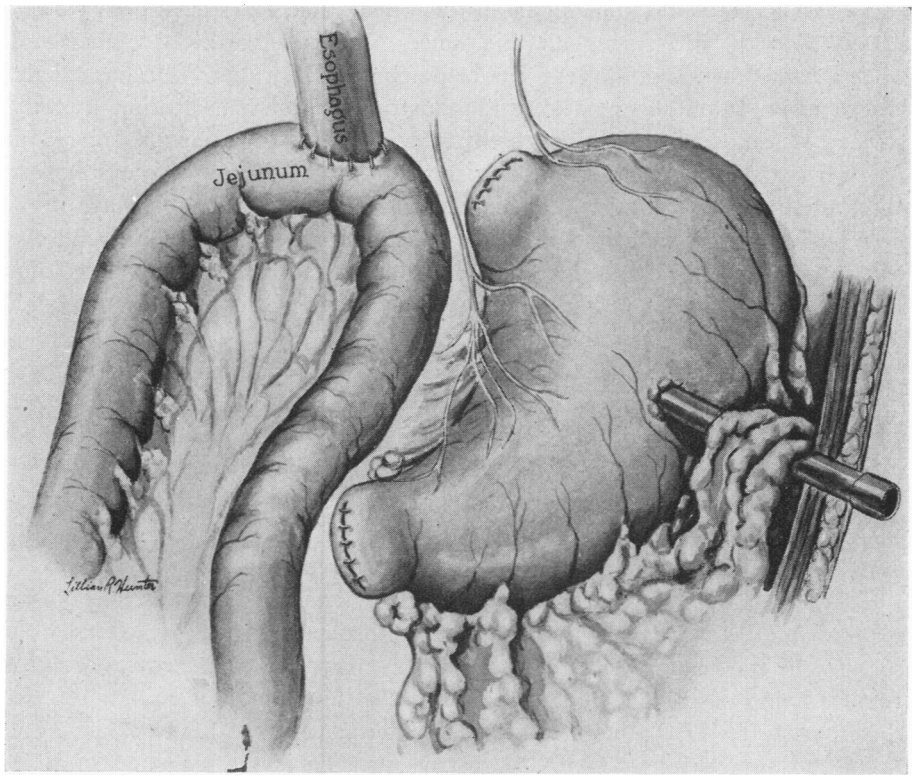

FIG. 1.—Diagram illustrating the totally isolated stomach preparation with preservation of the vagus innervation and blood supply.

gastric secretion to normal or subnormal values. The importance of the vagus nerves in the normal mechanism of gastric secretion has been recognized since the classical researches of Pavlov, and his pupils. However, it is possible that the discovery of humoral factors also effecting gastric secretion, notably gastrin and histamine, has directed the attention of many students to this phase of gastric physiology and has led to the employment of humoral stimuli exclusively in testing gastric secretory function in health and disease. Reliable data on the total volume of gastric juice secreted by normal man in 24 hours are very meager. There seems to be no way to apply the usual normal stimuli to the gastric glands and still recover the secretory product.

There is also little or no information concerning the relative proportion of gastric juice that is elicited by neurogenic stimuli and by humoral factors.

Some data bearing on this problem have been recently obtained in our laboratory, the details of which will be reported elsewhere. In this work, total isolated stomach pouches were prepared in dogs by the method of Dragstedt and Ellis.[3] The lower end of the esophagus was mobilized and the vagus nerves carefully pushed aside. The esophagus was then transected and the upper end of the stomach infolded and closed. The pylorus was then

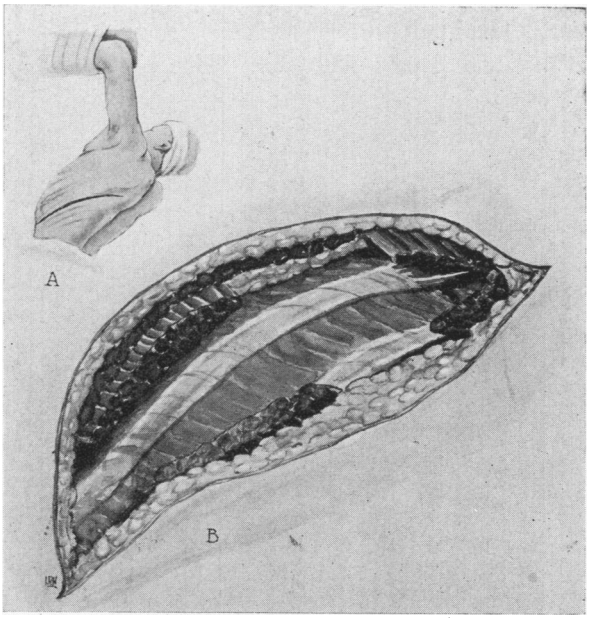

FIG. 2.—Incision (A) and exposure (B) of the 7th rib for transthoracic vagotomy.

transected, both ends infolded and closed, and the jejunum brought up and anastomosed to the esophagus by end-to-side suture. A gold plated cannula was inserted into the isolated stomach for the collection of gastric juice (Fig. 1). In a typical experiment such an isolated stomach, in which the blood supply and the vagus innervation had been carefully preserved, was found to secrete an average of 1,100 cc. of gastric juice with a free hydrochloric acid concentration of 0.35 to 0.42 per cent in 24 hours. The total secretion for a month was collected and then the vagus nerves were divided in the chest just above the diaphragm. The volume of gastric juice immediately declined to an average of 410 cc. with a free acidity of 0.11 to 0.32 per cent, and this effect persisted for at least 60 days.

By this type of experiment it was found that section of the vagus nerves to the stomach reduced the secretion of gastric juice in dogs to a half or even a fourth of the normal level. Unless it should develop that psychic factors are more important in gastric secretion in dogs than in man, it appears highly

probable that a similar reduction can be expected. The data obtained so far, suggest that the hypersecretion of gastric juice in ulcer patients is neurogenic in origin and that, consequently, a comparatively greater reduction should follow vagus section in man than in lower animals.

At the present time, 39 patients have been treated by vagus section in this Clinic. In 32 of these, the vagi have been divided in the left chest just above the diaphragm. The technic of this operation is illustrated in Figures 2, 3, and 4. An extensive resection of the seventh or eighth rib together with a portion of the cartilage is made so that retraction of the wound will produce minimum trauma. The intercostal nerve is isolated at the posterior margin of the wound, divided and ligated with silk. This procedure minimizes post-

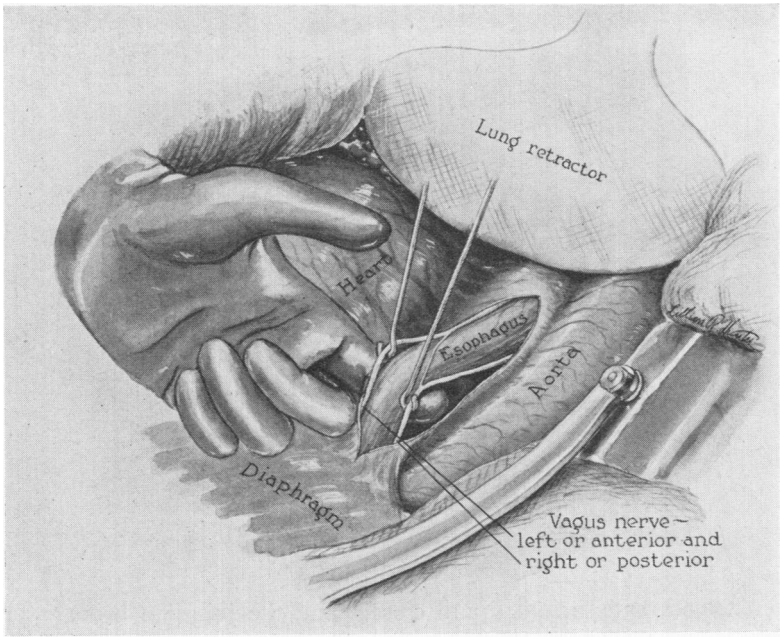

FIG. 3.—Mobilization of the esophagus and isolation of vagus nerves showing the communication between the anterior and posterior trunks.

operative pain in the chest, otherwise a troublesome complication. The inferior pulmonary ligament is clamped, cut, and ligated and the incision in the parietal pleura carried backward toward the aorta about 2 cm. The finger is then introduced through this aperture and the esophagus mobilized into the left chest by gentle blunt dissection. The vagus nerves may be easily identified by palpation, ligated with silk and divided as in Figure 3. The proximal ends of the divided nerves are sutured into the left pleural cavity to hinder regeneration. The chest is closed without drainage.

In seven of the patients, the vagus nerves have been divided below the diaphragm, usually because an associated high grade pyloric stenosis necessitated a gastro-enterostomy or resection to relieve obstruction. The method

employed is illustrated in Figures 5, 6 and 7. An inverted T-shaped incision (Fig. 5A) provides good access to the lower esophagus. The left triangular ligament of the liver is incised and the left lobe of the liver retracted medially (Figs. 5B and C). The peritoneal fold over the esophagus is severed and the esophagus mobilized by blunt dissection and pulled downward into the abdomen. Often 5 cm. or more of esophagus may be delivered into the abdomen by this method. The left, or anterior vagus nerve is found along the lesser curvature usually in the form of several separate strands which

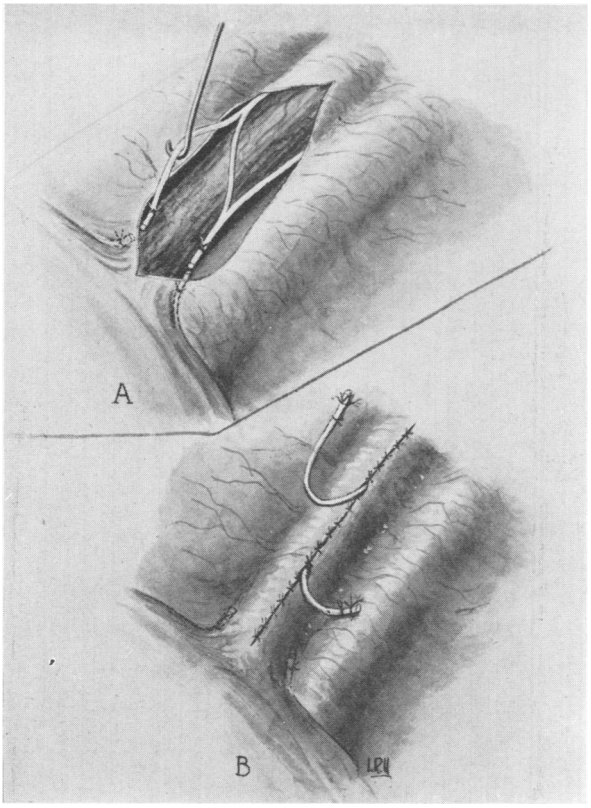

FIG. 4.—(A) Ligature and division of vagus nerves just above diaphragm; and (B) transplantation of proximal ends of cut vagi into the pleural cavity.

can be grouped together. The right, or posterior vagus is found along the greater curvature. It is most important to clear the esophagus of all nerve fibers for a distance of 2 or 3 cm. and to divide all the fibers passing to the stomach through the diaphragm. It is somewhat more difficult to secure a complete vagotomy by this abdominal approach but it can be accomplished if sufficient care is exercised. The nerve trunks are cut between silk ligatures and the proximal ends permitted to retract into the mediastinum, or they may be sutured to the diaphragm as in Figure 7.

The insulin test, as suggested by Hollander,[4] has been employed in our

TABLE I

TABULATED SUMMARY OF DATA ON PATIENTS UPON WHOM SECTION OF THE VAGUS NERVES WAS PERFORMED FOR GASTRODUODENAL ULCER

Patient	Unit No.	Age and Sex	Duration of Symptoms Years	Diagnosis	Direct Visualization of Ulcer with Gastroscope	Roentgen-ray Evidence of Ulcer Crater	Pyloric Stenosis	Hemorrhage	Perforation	Volume Preop. Night Secretion	Volume Postop. Night Secretion	Preop. Free Acid	Postop. Free Acid	Date of Vagus-Section	Remarks
H. F.	344351	54 ♂	20	Duodenal ulcer	−	+	+++	++	+	1142	395	44	35	10–25–44	Subdiaphragmatic vagotomy plus gastro-enterostomy. Complete relief. No recurrence to 5–10–1945
H. W.	329519	55 ♂	20	Duodenal ulcer	−	+	+++	++	−	1241	902	32	0	11–10–44	Subdiaphragmatic vagotomy plus gastro-enterostomy. Complete relief. No recurrence to June, 1945
C. B.	345581	42 ♂	26	Gastro-enterostomy 1928 Gastrocolic fistula 1930 Partial gastrectomy 1938 Gastrojejunal ulcer	−	+	−	+	+	200	177	13	0	11–18–44	Supradiaphragmatic vagotomy. Slight relief. Total gastrectomy July, 1945
M. B.	285298	56 ♂	12	Gastro-enterostomy 1942 Gastrojejunal ulcer	−	+	−	++	−	1021	412	22	36	11–24–44	Gastro - enterostomy taken down. Supradiaphragmatic vagotomy. Complete relief. No recurrence to June, 1945
J. W.	293108	60 ♂	25	Gastro-enterostomy 1936 Gastrojejunal ulcer	+	+	−	−	−	1220	338	20	0	11–27–44	Supradiaphragmatic vagotomy. Pain in incision, ulcer pain relieved. No recurrence to July, 1945
A. W.	346494	47 ♂	15	Gastro-enterostomy 1942 Gastrojejunal ulcer	−	+	−	++	0	566	361	0	0	12–11–44	Supradiaphragmatic vagotomy. Complete relief, with no recurrence to Feb. 1945
H. K.	345881	38 ♂	20	Duodenal ulcer	−	+	+	−	−	723	65	39	24	12–27–44	Supradiaphragmatic vagotomy. Complete relief. No recurrence to 5–6–45
H. M.	325181	30 ♂	7	Duodenal ulcer	−	+	+	+	−	775	428	36	6	12–29–44	Supradiaphragmatic vagotomy. Complete relief. No recurrence to May, 1945
N. K.	330562	48 ♂	7	Duodenal ulcer	−	+	+	+	−	717	400	55	19	1–3–45	Supradiaphragmatic vagotomy. Complete relief. No recurrence to April, 1945
M. C.	57621	54 ♂	20	Duodenal ulcer	−	±	−	±	−					1–5–45	Supradiaphragmatic vagotomy. Death from pneumonia

E. T.	347888	60 ♀	15	Duodenal ulcer	−	+	++	−	−	786	358	44	0	1–8–45	Supradiaphragmatic vagotomy. Complete relief. No recurrence to July 1945
R. V.	343287	42 ♂	1	Duodenal ulcer	−	−	+	−	−	1043	486	82	61	1–10–45	Supradiaphragmatic vagotomy. Complete relief. No recurrence to April, 1945.
W.H.S.	345905	52 ♂	26	Duodenal ulcer	−	+	++++	−	−	1165	893	35	25	1–19–45	Subdiaphragmatic vagotomy plus gastro-enterostomy. Complete relief. No recurrence to April, 1945
J. P.	349287	54 ♂	8	Duodenal ulcer	−	−	+++	−	−	405	571	23	14	1–19–45	Subdiaphragmatic vagotomy plus gastro-enterostomy. Complete relief. No recurrence to April, 1945
W. W.	351791	57 ♂	2	Duodenal ulcer	−	−	++	−	++	756	523	54	15	2–23–45	Supradiaphragmatic vagotomy. Complete relief. No recurrence to July, 1945
G. P.	328604	48 ♂	20	Subtotal gastrectomy 4–3–44. Gastrojejunal ulcer	−	+	−	−	−	1126	233	12	0	3–12–45	Supradiaphragmatic vagotomy. Complete relief. No recurrence to July, 1945
M. S.	204878	42 ♂	6	Subtotal gastrectomy 1943. Gastrojejunal ulcer	−	+	−	+	−	310	395	6	0	3–23–45	Supradiaphragmatic vagotomy. Complete relief. No recurrence to June, 1945
G. K.	76605	43 ♂	4	Gastric ulcer	+	+	−	−	−	460	248	31	14	3–21–45	Supradiaphragmatic vagotomy. Roentgen-rays show marked decrease in ulcer crater in 6 weeks
W. K.	355373	52 ♂	15	Duodenal ulcer	−	+	+	−	−	1086	295	46	11	4–13–45	Supradiaphragmatic vagotomy. Complete relief. No recurrence to July 1945,
C. W. O.	4977	42 ♂	16	Duodenal ulcer	−	−	+			642	212	66	2	4–18–45	Supradiaphragmatic vagotomy. Complete relief. No recurrence to July, 1945
J. A.	333605	44 ♂	15	Duodenal ulcer	−	+	+++	−	−	627	347	35	0	5–20–45	Subtotal gastrectomy, plus subdiaphragmatic vagotomy. Complete relief. No recurrence to August, 1945
G. H.	270528	47 ♂	15	Duodenal ulcer	−	+	++			1838	630	19	0	6–20–45	Subdiaphragmatic vagotomy plus gastro-enterostomy. Complete relief. No recurrence to August, 1945
J. G.	359155	31 ♀	15	Duodenal ulcer	−	+	+	−	−	881	238	43	17	7–2–45	Subdiaphragmatic vagotomy.
T. M.	358801			Duodenal ulcer	−	+	−	++	−	1138	494	78	25	7–23–45	Supradiaphragmatic vagotomy.

work to determine if all the vagus secretory fibers to the stomach have been interrupted. This test depends upon the fact that the hypoglycemia induced by an adequate dose of insulin stimulates the vagus secretory fibers to the stomach probably by an effect on the central nervous system. As a rule, the injection of 20 units of insulin in a normal adult produces a fall in the blood

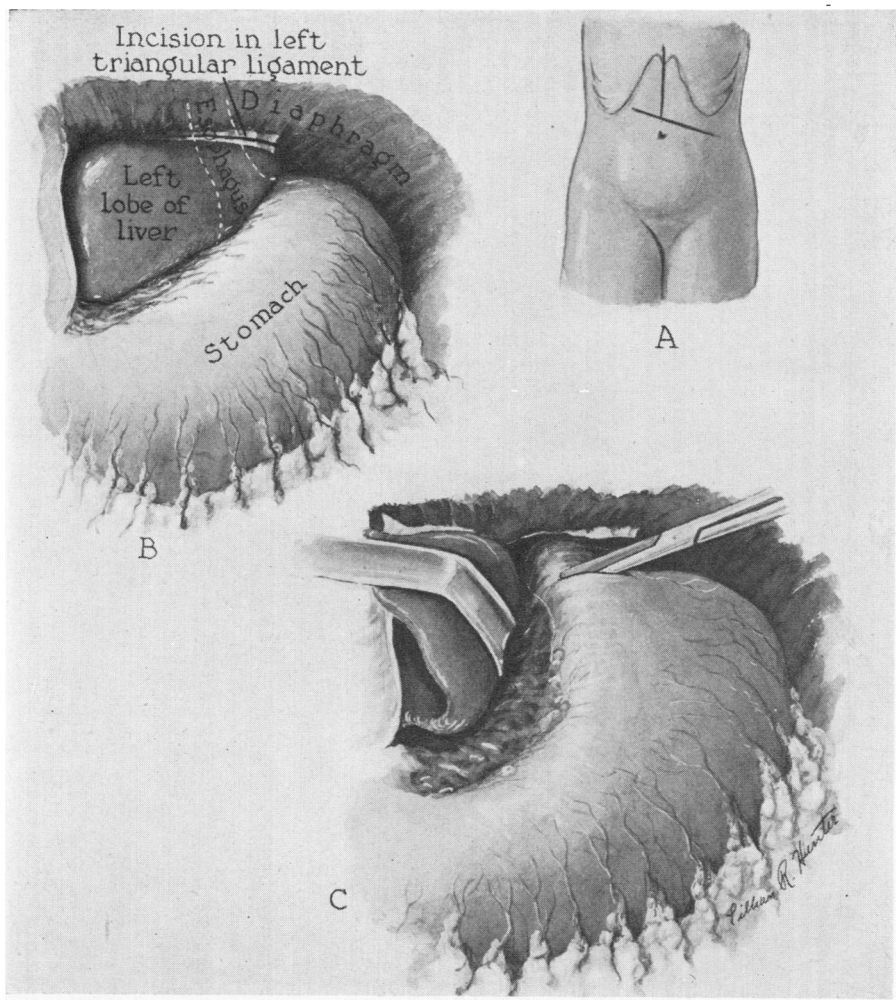

FIG. 5.—(A) Incision for transabdominal vagotomy. (B) Division of the left triangular ligament to the liver. (C) Exposure of esophagus.

sugar to 40 mg. or lower, and in about 30 minutes to an hour a marked augmentation in the rate and acidity of the fasting secretion results. No effect whatever occurs if the vagus section has been complete. The test must be controlled by estimations of the blood sugar before and one hour after the injection of insulin. The sugar must fall to 50 mg. or lower or no stimulation of the vagi is produced. In the last 21 patients, a positive response to the injection of insulin was obtained in 19 before operation, and this was

completely absent after the vagus section, except in one case where a doubtful positive response occurred in one test.

The data concerning the first 15 patients subjected to vagus section have been summarized in a previous report.[1] A tabulated summary of the remaining 24 is included here, Table I. Brief protocols of relevant data in the histories of these patients are also presented.

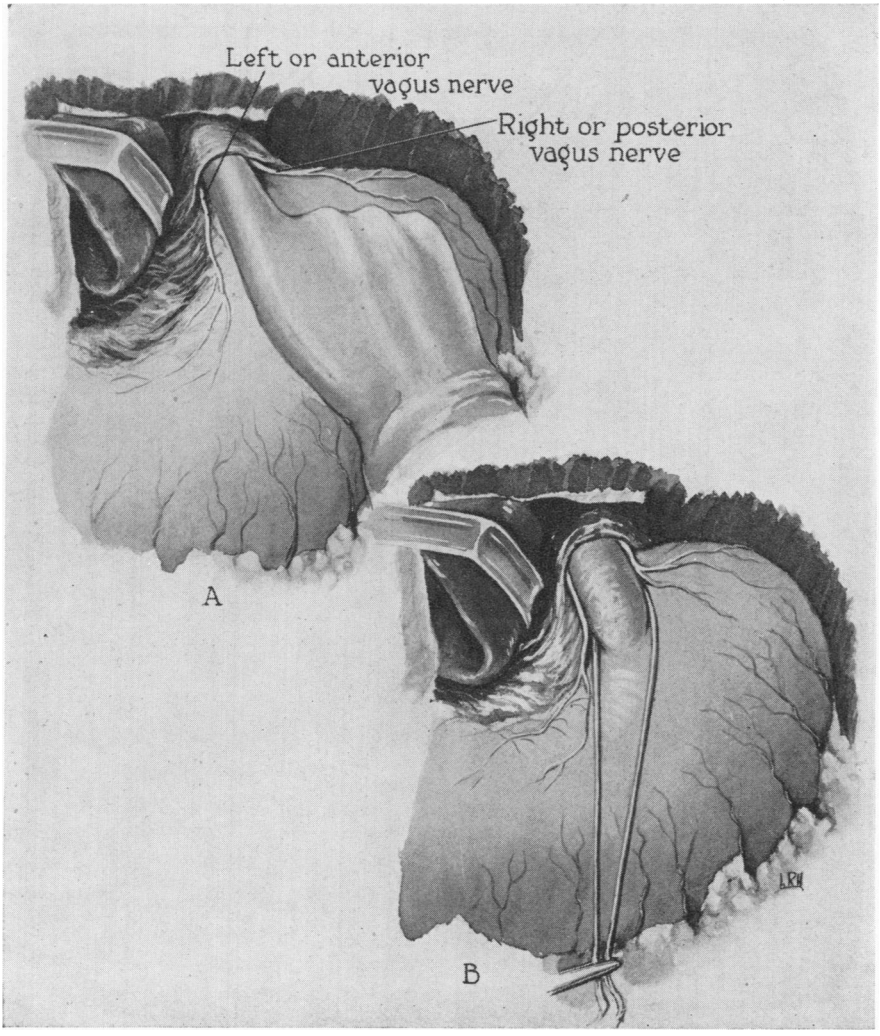

FIG. 6.—(A and B) Mobilization of esophagus.

It will be noted that one of the 39 patients died, a mortality for the operation at present of 2.5 per cent. This patient developed a postoperative bronchopneumonia due, in part to the aspiration of regurgitated material which had accumulated in the stomach. It is now our practice to maintain constant intragastric suction for three to four days after operation or until

the stomach has recovered sufficient tonus to prevent the accumulation of more than 200 cc. of fluid. There have been no other serious postoperative complications. As noted before, pain along the rib margin was a troublesome development in many of the early cases. This has been very largely prevented by the division of the intercostal nerve at the posterior margin of

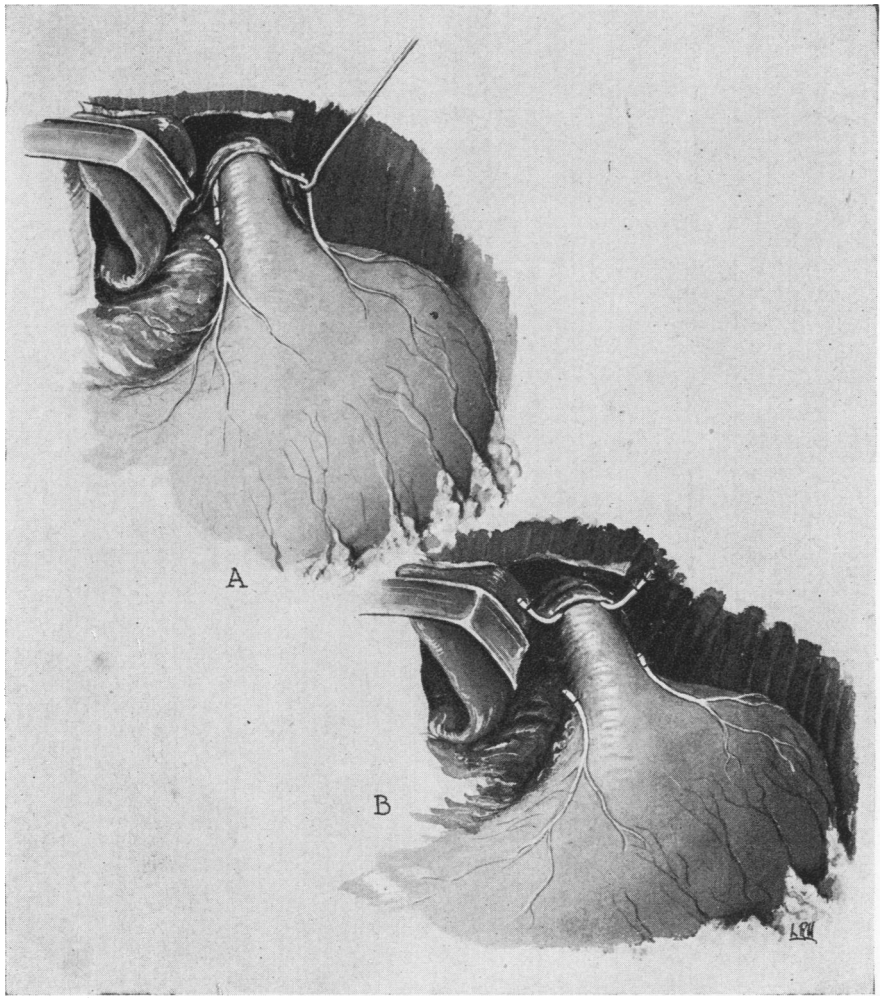

FIG. 7.—Isolation and division of vagus trunks.

the wound. It is probable that a pleural effusion of varying amount occurs in all patients, but this has required aspiration in only 25 per cent. A second aspiration was performed three times. There is undoubtedly a hazard from atelectasis and bronchopneumonia. The practice of early rising has probably lessened the incidence of these complications. Almost all of the patients get out of bed after 24 hours and remain so for long periods on the third or fourth day.[5]

Thirty of the patients subjected to vagus section had duodenal ulcers, two had gastric ulcers and seven had gastrojejunal ulcers. Eight of the duodenal ulcer patients were given a gastro-enterostomy in addition to the vagus section because of high grade pyloric stenosis. In five of these the vagus section was done by the abdominal approach at the same time as the gastro-enterostomy. Only one of the duodenal ulcer patients failed to obtain striking and persistent relief of symptoms, and in this case there were many features suggesting a neurosis. The first patients have been followed for two and one-half years and, so far, have remained well on unrestricted diets and without medication. One of the patients with gastric ulcer has been entirely cured of his disease as determined by gastroscopic and roentgenographic evidence and complete relief of symptoms. The other has been relieved of distress, and at the last examination a marked reduction in the size of the ulcer crater was apparent. The status of vagus section for gastrojejunal ulcers is more uncertain. These ulcers are notoriously difficult to heal without resection. Of the seven patients with this lesion, one was dissatisfied with the result and went to another clinic where a total gastrectomy was performed. One patient secured complete relief of distress only with additional alkalies, but was able to return to work as a sailor and has not been seen during the past year. The remaining five have secured complete relief of ulcer distress, and in three of these, a spectacular recession in the craters, visualized roentgenographically, has been obtained. A longer period of observation is required before conclusions can be drawn in this group.

Studies on the effect of vagus section on gastric secretion and motility in ulcer patients have been made, and will be reported in detail elsewhere. The operation has no effect on the secretory response of the stomach to histamine or caffeine but abolishes the stimulating effect of insulin hypoglycemia and a sham meal. Confirming our earlier experience, the most definite and consistent secretory abnormality in ulcer patients is an abnormally large continuous secretion of gastric juice in the empty stomach at night when there is no apparent stimulus. This occurred without exception. Vagotomy reduced this secretion from 50 to 60 per cent, indicating that it is largely neurogenic in origin. The tonus and hunger contractions of the stomach in patients with duodenal ulcer are usually excessive and are reduced but not abolished by vagotomy. A temporary atony of the fundic region was observed in two patients by fluoroscopy. It is very likely that this reduction in hypertonicity in part accounts for the immediate symptomatic relief so commonly produced. Although a decrease in the motility of the stomach was found in each case when the examination was made, no evidence has been obtained, so far, indicating a similar decrease in the motility of the intestines. If any effect at all has been produced, it is in the direction of increased peristalsis. A considerable proportion of the patients who complained of constipation before the operation have been even more gratified by the disappearance of this disturbance than by the relief of the ulcer distress. Further study of this effect is necessary.

CLINICAL PROTOCOLS

H. F. (Unit No. 344351), a 54-year-old white male, was first seen in this clinic on October 18, 1944. He gave a history of epigastric distress for the previous 20 years, during which time he secured partial relief by food and alkalies. Eight years ago he had an attack of nausea and vomiting and a profuse gastric hemorrhage. Shortly after this attack he was operated upon for a perforated duodenal ulcer. After recovery from the operation he followed an ulcer management with frequent feeding and powders faithfully. When he came to this clinic his abdominal pain had become more severe, vomiting was frequent and he had passed tarry stools for the preceding two days. Roentgenologic examination revealed a duodenal ulcer with a crater and high grade pyloric obstruction. On October 25, 1944, a celiotomy was performed and a stenosing duodenal ulcer demonstrated. The lower esophagus was mobilized, the vagus nerves ligated and divided, and a posterior gastro-enterostomy made. Recovery from the operation was uneventful, and the patient has had no epigastric distress of any kind subsequently. When last seen in May, 1945, he was eating a regular diet, without medication, and had no distress.

C. B. (Unit No. 345581), a 42-year-old white male, was first admitted to the clinic on November 7, 1944. He complained of epigastric distress occurring several hours after meals and at night ever since he was 16 years old. The ingestion of food or milk always relieved the pain. In 1928, a posterior gastro-enterostomy was done for duodenal ulcer. Following this operation his abdominal pain persisted and he developed diarrhea. He was operated upon again in 1930, at which time a gastrojejunocolic fistula was found. This was closed and the gastro-enterostomy taken down. The epigastric pain persisted and, in 1938, a subtotal gastrectomy was performed. This provided temporary relief, but early in 1944 symptoms recurred, and roentgenologic examination revealed a gastrojejunal ulcer. Medical management provided only partial and temporary relief and he began to vomit. Roentgenologic examination in this clinic on November 14, 1944, revealed a large jejunal ulcer. On November 18, 1944, a transthoracic supradiaphragmatic section of the vagus nerves was performed. Recovery was uneventful. On February 28, 1945, roentgenologic examination revealed a decrease in the size of the ulcer crater. The epigastric distress improved and he began to eat very well, but was severely injured in an automobile accident in 1945. He recovered from this accident but his epigastric distress recurred and he entered another clinic where a total gastrectomy was performed.

H. W. (Unit No. 329517), a 55-year-old white male, was first seen in this clinic on March 14, 1944. For the preceding 20 years he had been having epigastric pain after meals and at night. No adequate therapy was given during this period. On two occasions in 1943 he had massive gastro-intestinal hemorrhages. On June 24, 1944, roentgenologic examination revealed a duodenal ulcer with deformity of the duodenal bulb, stenosis and a crater. Medical management gave only partial relief. On November 10, 1944, a posterior gastro-enterostomy and a subdiaphragmatic section of the vagus nerves was performed. For several weeks after operation, the anastomosis functioned poorly. However, after two months he was able to eat regularly without distress, and by June, 1945, he gained 30 pounds in weight. At this time he was eating a regular diet, without powders, and had no epigastric pain.

M. B. (Unit No. 285298), a 56-year-old white male, was first seen in this clinic on June 20, 1942. Twelve years before he began to have epigastric distress, consulted a physician who made a diagnosis of duodenal ulcer. He was placed on medical management and did fairly well until ten days before entering the hospital, when he developed severe epigastric pain and had a massive hemorrhage. Subsequently, roentgenologic studies showed a duodenal ulcer with a large crater. Roentgenotherapy to the stomach was given and considerable improvement resulted. In November, 1942, he developed obstructive symptoms and a posterior gastro-enterostomy was performed. He was well

for one year following this operation but then symptoms recurred, and roentgenologic examination revealed a gastrojejunal ulcer. Medical management failed to give relief.

On November 8, 1944, the gastro-enterostomy was taken down and on November 24, 1944, a transthoracic supradiaphragmatic section of the vagus nerves was performed. Recovery from both operations was uneventful and when last seen in June, 1945, he was entirely symptom-free and eating a regular diet without alkalies.

J. W. (Unit No. 293108), a 60-year-old male, was first seen in the clinic on September 15, 1942. He gave a history of epigastric distress for the previous 25 years. In 1936, a gastro-enterostomy was performed. Epigastric distress recurred in 1940, and roentgenologic examination revealed a gastro-enterostomy and just above it, a large gastric ulcer. The ulcer was visualized with the gastroscope. Roentgenotherapy to the stomach was given and, on December 22, 1942, the ulcer disappeared, was not demonstrated on either roentgenographically or on gastroscopic examination. In August, 1943, symptoms recurred and the ulcer reappeared on the roentgenogram and on gastroscopy. Strict management was instituted with some decrease in the size of the ulcer but this increased again in the latter part of 1944.

On November 27, 1944, a transthoracic supradiaphragmatic section of the vagus nerves was performed. Recovery was uneventful but was complicated by persistent pain in the region of the incision, which has continued to the present. Roentgenologic examination, March 24, 1945, revealed a poorly functioning gastro-enterostomy with a stomal ulcer.

When last seen in June, 1945, the patient was eating fairly well, had little or no epigastric distress but still complained of pain in the chest.

A. W. (Unit No. 346494), a 47-year-old white male, was first admitted to the clinic on November 21, 1944. He complained of epigastric distress which had been present for the previous 15 years, and a diagnosis of a duodenal ulcer had been made. Diet and powders controlled the pain fairly well during this period. Symptoms recurred, however, and two years before entering the hospital, a gastro-enterostomy was performed elsewhere. Following this operation he was well until four hours before admission when he developed pain in his left side and began to vomit blood. The gastric hemorrhage was controlled and, on November 29, 1944, roentgenologic examination revealed a well-functioning gastro-enterostomy with a gastrojejunal ulcer with a crater. On December 11, 1944, a transthoracic supradiaphragmatic section of the vagus nerves was performed. Recovery from the operation was uneventful except for a slight pleural effusion on the left side which did not require tapping. Ulcer symptoms were entirely relieved and roentgenologic examination, January 9, 1945, failed to reveal the crater at the anastomosis. When last seen in February, 1945, he was free from distress, eating a regular diet, and taking no powders.

H. K. (Unit No. 345881), a 38-year-old white male, was admitted to the clinic on November 11, 1944. For the preceding 20 years he had been having intermittent gastric distress following meals. This was partly relieved by food and alkalies. Roentgenologic examination, November 15, 1944, revealed a duodenal ulcer with deformity and a small central crater. Medical management produced little or no effect. On December 27, 1944, a transthoracic supradiaphragmatic vagus section was performed. Recovery was uneventful. Roentgenologic examination, January 11, 1945, showed no change in the ulcer crater. On February 5, 1945, the crater appeared somewhat smaller and by May 10, 1945, it had completely disappeared on roentgenologic examination.

When last seen on May 6, 1945, he was eating a liberal diet, without powders, and without distress.

H. M. (Unit No. 325181), a 30-year-old white male, was first admitted to the hospital on January 12, 1944. Seven years previously he had epigastric pain occurring after meals. Roentgenologic examination was made, with a diagnosis of duodenal ulcer. Medical management produced marked relief but at intervals the epigastric distress recurred. Two months ago, he began to vomit and the abdominal pain became more

severe. On one occasion he had a severe hemorrhage. Roentgenologic examination revealed a duodenal ulcer, with deformity and a large ulcer crater. Roentgenotherapy to the stomach was given and the crater decreased somewhat in size but did not disappear. He did fairly well on medical management but on July 27, 1944, was readmitted to the hospital because of a massive hemorrhage. This was controlled and, December 29, 1944, a transthoracic supradiaphragmatic section of the vagus nerves was performed. Recovery was complicated by pleural effusion which required aspiration. Roentgenologic examination, April 11, 1945, revealed disappearance of the ulcer crater and no obstruction, but a persistent deformity of the duodenal bulb.

When last seen on May 15 he had no epigastric distress, was eating a regular diet and had gained 30 pounds since the operation.

N. K. (Unit No. 330562), a 48-year-old white male, was admitted to the clinics on March 28, 1944. For the preceding seven years he had been having intermittent epigastric pain coming on several hours after meals and relieved by food and alkalies. He passed black tarry stools at intervals but did not vomit blood. In 1942, he was operated upon elsewhere for ulcers of the stomach but the nature of the operation was not determined. The epigastric distress persisted and roentgenologic examination in this clinic, March 30, 1944, revealed a marked ulcer deformity of the duodenal bulb with a central crater. In April, 1944, he was given roentgenotherapy to the stomach and medical management. The symptoms were relieved and the crater disappeared. In December, 1944, the epigastric pain recurred, roentgenologic examination showed marked deformity but no crater. On January 3, 1945, a transthoracic supradiaphragmatic section of the vagus nerves was performed. Recovery was complicated by pain in the chest and from gastric distention. When last seen on April 5, 1945, he was eating a regular diet, without powders, and had no epigastric distress. He had gained 20 pounds since the operation.

M. C. (Unit No. 57621), a 54-year-old white male, was first seen in this clinic in 1932. He gave a history of epigastric distress of the ulcer type for the previous 20 years. Roentgenologic examination revealed deformity of the duodenal bulb with marked pyloric stenosis. A posterior gastro-enterostomy was performed. In June, 1934, his ulcer pain recurred, and roentgenologic studies revealed a gastrojejunal ulcer. Medical management gave only partial relief and, in December, 1934, the gastro-enterostomy was taken down. Within a few months his ulcer symptoms appeared again and persisted in spite of rigorous medical management combined with roentgenotherapy to the stomach to decrease gastric secretion. On January 5, 1945, a transthoracic supradiaphragmatic section of the vagus nerves was done. Following operation, he developed gastric distention, and on one occasion aspirated a considerable amount of vomitus. A bronchopneumonia developed and death occurred on January 13, 1945. Autopsy was not permitted.

E. T. (Unit No. 347888), a 60-year-old white female, was first seen in this clinic on December 13, 1944. She complained of epigastric pain after meals for the previous 15 years. One year ago, a roentgenologic examination was made, with a diagnosis of duodenal ulcer. Symptoms were relieved by medical management, but in July, 1944, she began to vomit. Roentgenologic examination on December 13, 1944, revealed partial pyloric obstruction due to a duodenal ulcer, with a crater. On January 8, 1945, a transthoracic supradiaphragmatic section of the vagus nerves was performed. Recovery was complicated by fever which persisted for a week, and a pleural effusion. Following operation, she was able to eat a soft diet without vomiting. No medication was given. Roentgenologic examination on January 30, 1945, showed some improvement in the pyloric obstruction but persistence of an ulcer crater in the duodenum. On May 8, 1945, the pyloric obstruction was markedly improved although the stomach was still somewhat dilated. When last seen on May 12, 1945, she was eating a liberal diet, without medication, and without epigastric distress or vomiting. Her only complaints were occasional sharp jabbing pain in the region of the incision.

R. V. (Unit No. 343287), a 42-year-old white male, was first admitted to the clinic on October 5, 1944. He gave a history of intermittent epigastric distress of the ulcer type for the previous eight months. For the past four months the pain had been particularly severe. Roentgenologic examination revealed a deformity of the duodenal bulb but no crater. Medical management failed to relieve the distress. On January 10, 1945, a transthoracic supradiaphragmatic section of the vagus nerves was performed. Recovery from the operation was uneventful, and all epigastric symptoms were immediately relieved. When last seen, March 31, 1945, he was feeling well, eating a liberal diet without distress or medication.

W. H. S. (Unit No. 345905), a 52-year-old white male, was first seen in the clinic on November 13, 1944. For the preceding 26 years he had been having periodic attacks of severe epigastric pain relieved by food and alkalies. In 1929, these attacks began to be associated with vomiting. Roentgenograms revealed a duodenal ulcer. On medical management he remained fairly well until 1938, when the epigastric pain and vomiting became more severe. These symptoms continued and were associated with a loss of 20 pounds in weight during the five months before admission to the clinics. Roentgenologic examination at this time revealed almost complete pyloric obstruction. On January 19, 1945, a posterior gastro-enterostomy was performed, and at this time the vagus nerves were divided immediately beneath the diaphragm. Recovery from the operation was uneventful and during the first three months the patient gained 30 pounds in weight. When last seen March 27, 1945, he was eating a regular diet, without medication, and without epigastric distress.

J. P. (Unit No. 349287), a 54-year-old white female, was admitted to this clinic on January 10, 1945. She complained of intermittent epigastric pain that was relieved by food and alkalies for the preceding eight years. For the past two years this was associated with vomiting and a loss of 35 pounds in weight. Roentgenology examination, January 10, 1945, revealed marked pyloric obstruction probably due to duodenal ulcer but no crater was visualized. On January 19, 1945, a celiotomy was performed by Dr. William Adams which revealed a large duodenal ulcer with adhesions. The esophagus was mobilized and the vagus nerves isolated. A segment, approximately one inch in length was resected from each vagus nerve. An anterior gastro-enterostomy was then performed. Recovery from the operation was complicated by a severe blood transfusion reaction. When last seen, March 30, 1945, she was feeling well, had no epigastric distress and was eating a regular diet, without powders.

W. W. (Unit No. 351791), a 57-year-old white male, was first admitted to this clinic on February 16, 1945. He reported that he had been entirely well until November, 1943, when he developed a severe epigastric pain for which an emergency operation was performed. A perforated duodenal ulcer was found, and closed. He remained well until December, 1944, when he again had a perforated duodenal ulcer for which he was operated upon and which was again closed. He remained well then until February, 1945, when he developed an attack of severe upper abdominal pain with vomiting. Nine days after this attack he was admitted to the hospital for observation. Roentgenologic examination, February 19, 1945, revealed marked deformity of the duodenal bulb and pyloric stenosis of moderate degree. A crater was not demonstrated. On February 23, 1945, a supradiaphragmatic transthoracic section of both vagus nerves was performed. Recovery from the operation was uneventful. When last seen on July 24, 1945, he stated that he had been completely relieved of all ulcer symptoms since the operation. He was eating a liberal diet without distress or vomiting, and took no medication of any kind.

G. P. (Unit No. 328604), a 48-year-old white male, was admitted to the clinic on March 2, 1944. Twenty years before he first experienced abdominal pain accompanied by nausea and vomiting. A diagnosis of duodenal ulcer was made. Medical treatment proved unsuccessful and, in 1925, a gastro-enterostomy was performed. This gave only temporary relief and, in 1939, roentgenologic studies revealed a gastrojejunal ulcer. He

continued to have epigastric distress with occasional episodes of vomiting during the ensuing five years. When he entered the clinic, roentgenologic examination of the stomach, March 8, 1944, revealed a large gastrojejunal ulcer. On April 3, 1944, the gastro-enterostomy was taken down and a subtotal gastrectomy was performed. Symptoms were entirely relieved until February, 1945, when the abdominal pain returned. Roentgenologic examination, February 14, 1945, revealed the reappearance of a very large gastrojejunal ulcer. On March 12, 1945, a transthoracic supradiaphragmatic section of the vagus nerves was performed. Immediate relief followed this operation and he was able to eat a liberal diet, without medication. Subsequent roentgenologic studies, April 30, 1945, showed almost complete disappearance of the ulcer crater.

M. S. (Unit No. 204878), a 36-year-old male, was first seen on August 29, 1938. For the past two months he had been complaining of typical ulcer distress and roentgenologic examination revealed a duodenal ulcer, with a crater. Symptoms were controlled for a time on medical management but recurred in 1943, at which time a subtotal gastrectomy was performed. At operation, a chronic duodenal ulcer penetrating into the pancreas was found. Six months after the operation a recurrence of symptoms developed and a gastrojejunal ulcer was demonstrated roentgenologically. Roentgenotherapy to the stomach was then given, with relief of symptoms, and there was apparent disappearance of the ulcer. The ulcer recurred in six months and pain became severe. On March 23, 1945, a transthoracic supradiaphragmatic section of the vagus nerves was performed. Recovery was uneventful, and the patient was entirely relieved of ulcer distress. On May 9, 1945, roentgenologic examination failed to reveal any evidence of the gastrojejunal ulcer.

When last seen in June, 1945, he was symptom-free and ate a regular diet, without powders.

W. K. (Unit No. 355373), a 52-year-old white male, was first admitted to the clinic on April 9, 1945. He gave a history of typical ulcer distress for the preceding 15 years. Medical management had usually been successful in providing relief but frequent recurrences of pain and distress occurred. In the four months before entering the hospital the pain had been unusually severe and failed to respond to the usual therapy. Roentgenologic examination revealed a duodenal ulcer, with a large crater. On April 13, 1945, a transthoracic supradiaphragmatic section of the vagus nerves was performed. Recovery from the operation was uneventful and was followed by complete relief of his ulcer distress. When last heard from in July, 1945, he was eating a liberal diet, without medication, and experienced no abdominal pain or discomfort.

C. W. O. (Unit No. 4977), a 42-year-old white male, was admitted to the clinics on April 15, 1945. He gave a history of epigastric distress beginning in 1928, at which time roentgenologic examination revealed a duodenal ulcer. Medical management was faithfully carried out and this provided complete relief of all symptoms except during periods of severe mental strain. At this time, the pain recurred and interfered so much with his work as a trial lawyer that further treatment was desired. Roentgenologic examination revealed a deformity of the duodenal bulb but no crater. On April 18, 1945, a transthoracic supradiaphragmatic section of the vagus nerves was performed. Recovery from the operation was uneventful and following this, all of his ulcer symptoms have entirely disappeared. When last seen in July, 1945, he was eating a liberal diet, without medication, and had no ulcer symptoms.

CONCLUSIONS

1. Descriptions are given of methods for the division of the vagus nerve supply to the stomach in man by a transthoracic and an abdominal approach.
2. The vagus nerves to the stomach were divided in 30 patients with duodenal ulcers, in two with gastric ulcers, and in seven with gastrojejunal ulcers.

3. A striking and persistent relief of ulcer distress has been almost uniformly secured, with gain in weight, and roentgenographic evidence of healing of the lesions.
4. Section of the vagus nerves had no effect on the secretory response of the stomach to histamine or caffeine but abolished the response to insulin hypoglycemia and a sham meal.
5. The tonus and motility of the stomach were decreased but not abolished by the operation.

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